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Assessing vulnerability to vegetation growth on earth dikes using geophysical investigation

Benjamin Mary, Ginette Saracco , Laurent Peyras , Michel Vennetier , and Patrice Mériaux

The Mediterranean Basin is prone to a plethora of natural hazards including floods. Vegetation growth in hydraulic earth structures, such as flood protections or channel levees and dams, may induce several degradation mechanisms leading to a risk of failure. Typically, trees' rooting generates two types of risks: internal erosion from root development in earth embankments, and external erosion (slopes and crest) which is often related to trees uprooting. To better assess how woody vegetation can compromise levee integrity, we designed a methodology using acoustical and complex electrical tomography as non destructives methods to spot dangerous roots in the embankment.
Our work has been first initiated during laboratory experiments; we performed soundings in controlled conditions to determine both acoustical and electrical intrinsic behavior of our root samples. By comparison with soil samples we expected to point out specific signatures that would be useful for the roots anomaly identification in real conditions. Measurements were repeated on several samples to ensure statistical interpretation.

With help of an ultrasonic transmission device, we identified significant relative velocity differences of compressional waves propagation between soil and root samples. We also studied spectral properties using wavelet processing method as an additional parameter of root distinction with the surrounding soil. In the case of electrical soundings, complex resistivity was measured and we computed resistivity spectra. Amplitude of resistivity term showed us that root material behaves as an insulator compared to the soil. With the phase resistivity term information, root can also be seen as an electric power capacitance and reveals maximum polarization effect located around 1Hz.

Then, as experimental device for the field measurements, we selected a 320 cm high poplar (Populus) planted in a homogeneous loamy-clayed soil, which is the same soil used in laboratory experiment to keep comparable conditions. Validity of geophysics data obtained was compared with results from excavation of the first decimeters of soil which allowed defining actual position, geometry and size of root system.

For acoustical prospection, we reproduced RINNTECH® methodology on field. The technique relies on measuring the travel time between two sensors, respectively a mobile source defining a mesh all around the tree and fixed receivers on the tree stem. Our results showed that information provided by the amplitude of recorded wave seemed more relevant than the velocity term to discriminate roots from the soil. Unfortunately the signal at very low frequency was noisy which prevents an easy interpretation of spectral properties. From electrical tomography measurements, high resolution inverted images were obtained and showed correlation between roots direction and depth, and phase anomalies. This result was yet found with a too low resolution.

Both complex resistivity tomography and acoustical prospection shows considerable promise to map tree roots. Considering a coupling approach is appreciable because each method is sensitive to a different physical parameter. This provides more information and facilitates the interpretation of variability observed in real conditions, where a lot of external parameters can disturb the information requested.